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Summer AIAD at Los Alamos National Laboratory (LANL)

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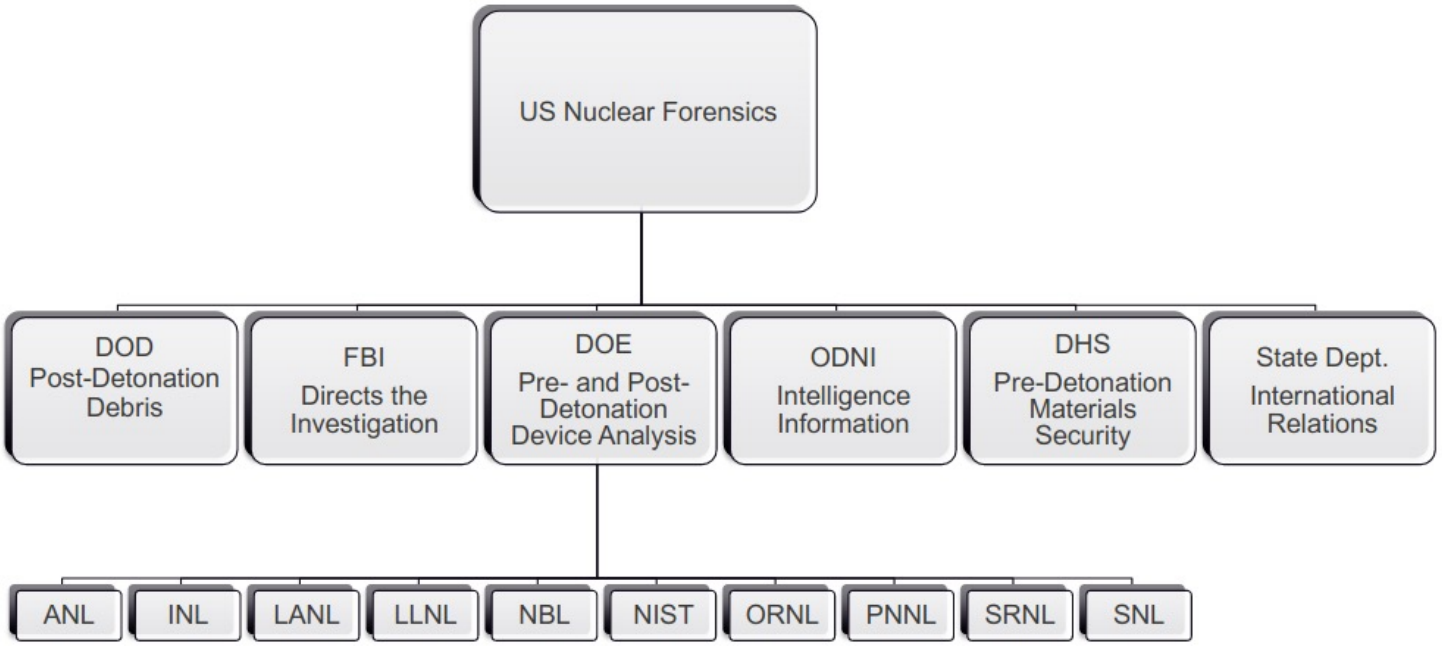
Intro to LANL's Post-Detonation National Technical Nuclear Forensics (NTNF) Program

- With over 70 years of nuclear weapons design, diagnostics, and analysis expertise, the NTNF team is able to answer the three key questions:
  - Who was it?
  - What was it?
  - Are there more?



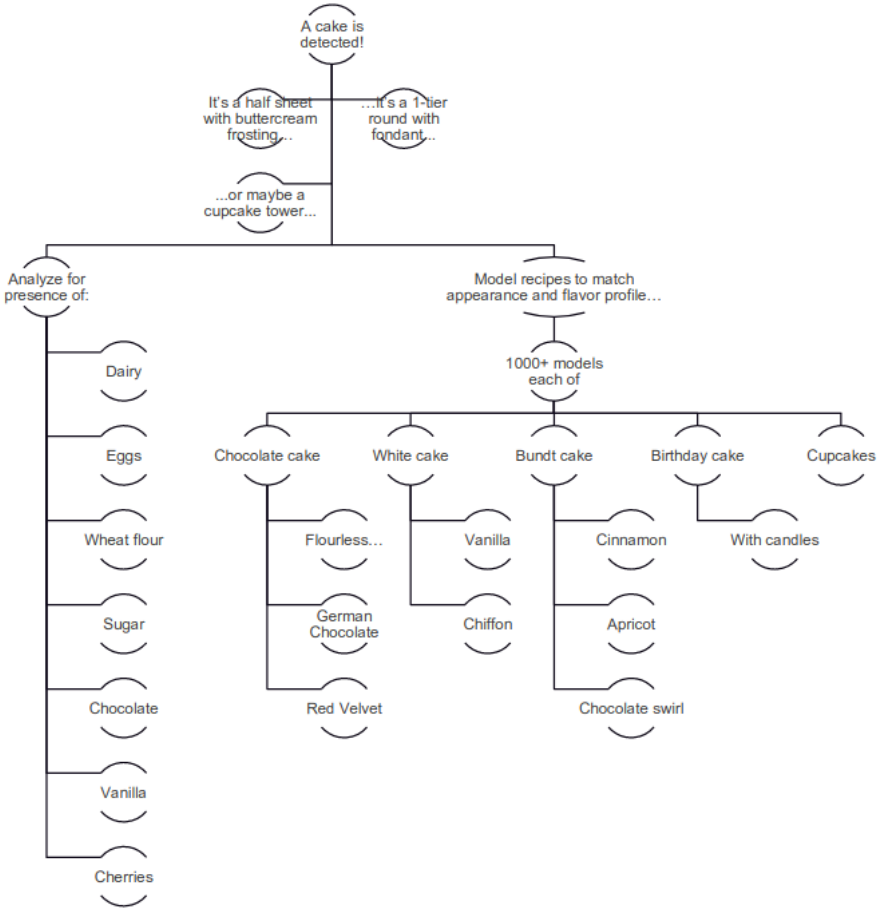
Post-Detonation NTNF Process

- If a nuclear detonation were to occur on U.S. Soil, we would begin analyzing samples and reporting on the data to inform policymakers with likely types of devices, ultimately determining where the device came from.

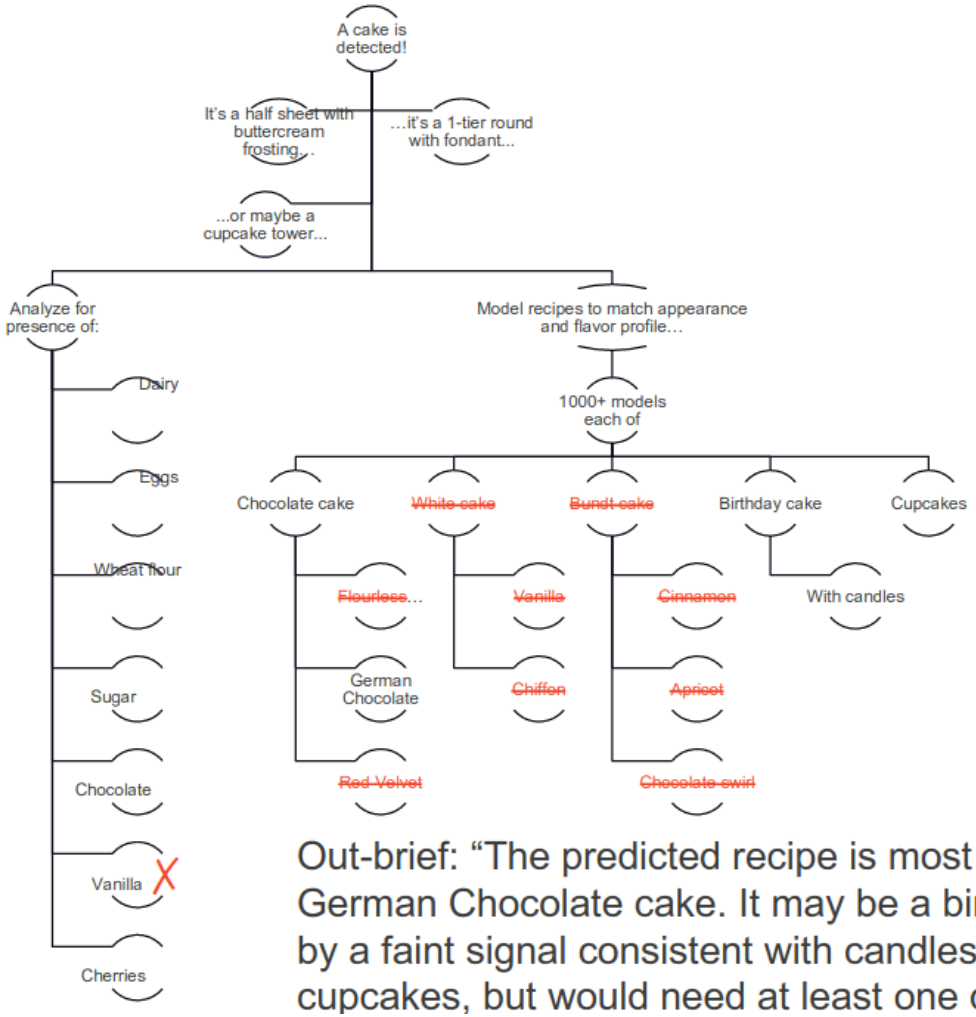
- Nuclear Forensics Post-Detonation:
  - Debris collection
    - Ground & air sample analysis.
  - Device Assessment
    - Advanced simulation & models with high performance computing.
  - Attribution
    - Provide statements such as “The complexity of the device indicates a nation-state attack” or “The simplicity of the device indicates little experience.”

Unbake-A-Cake Analogy

- NTNF process is similar to un-baking a cake. If there is a fully baked, ready-to-eat cake, with no details about it, questions arise:
  - Is it really a cake?
  - How was it made?
  - What are the ingredients?
  - Who made it?



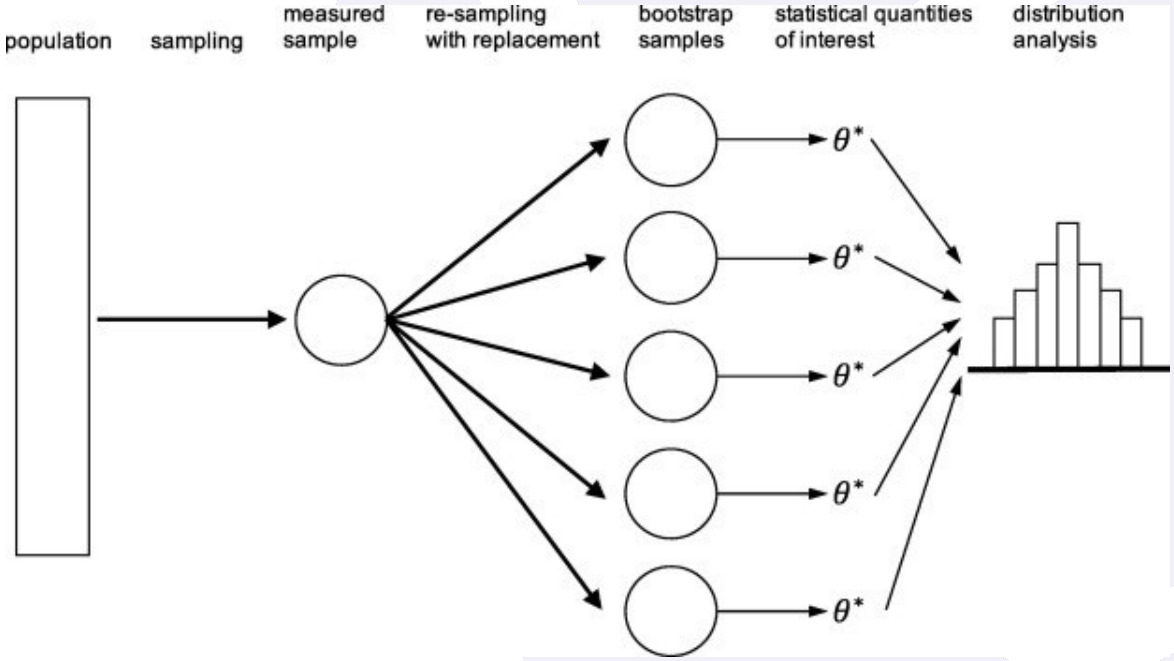
Unbaking-A-Cake Determination



Out-brief: "The predicted recipe is most consistent with a German Chocolate cake. It may be a birthday cake, indicated by a faint signal consistent with candles. We cannot rule out cupcakes, but would need at least one dozen."

My Project Tasking

- Develop a mathematically rigorous methodology for determining “Calibration-Factors.”
  - How well do we model known quantities?
  - How does our ability to model known quantities transfer to unknown quantities?
  - How do the different known quantities relate to each other?



Data Science Skills Gained

- To yield a good estimate of model parameter uncertainties, an ensemble-based statistical method can be used:
  - Bootstrap Method: re-sample ‘m’ # of measurements w/replacement (random choice), ‘j’ # of times to create ‘j’ surrogate data sets. Take the mean across ‘j’ data sets, and create a new distribution of the mean values, giving standard error.
  - Bootstrapping also can identify co-variance between ‘n’ model parameters.
  - The concept of a statistical distance (ex., Mahalanobis distance)
    - Quantifies the similarity of two distributions.